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Agroforestry Systems and Local Institutional Development for Preventing Deforestation in Chiapas, Mexico

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1. Introduction

The transformation of natural forest to secondary forest and pastures has been the most common process of land use change in tropical countries in recent decades (FAO, 2010). The main causes of deforestation include institutional factors, markets, public policies and global forces, which often act synergistically (Deininger and Minten, 1999; Bocco et al. 2001; Lambin et al., 2001).

Mexico is a country with $64{,}802 \times 10^3$ ha of forested land, and it is one of the ten countries with the largest area of primary forest (3% of total). The annual net loss of deforestation in Mexico has been estimated to be 0.52% for the period of 1990-2010, but the net loss, on average, has decreased over the past few years (FAO, 2010). The highest deforestation rates are concentrated in the south and central regions of the country, as documented elsewhere: 8.4% in el Nevado de Toluca, state of Mexico (1972-2000) (Maass et al., 2006); 8% in Patzcuaro, Michoacan (1960-1990) (Klooster, 2000); 6.9% in some areas of Campeche (Reyes-Hernández et al., 2003); 6.1% in the highlands of the state of Chiapas (Cayuela et al., 2006; Echeverría et al., 2007); and 2-6.7% in Selva Lacandona, also in Chiapas (Ortiz-Espejel & Toledo, 1998; de Jong et. al., 2000). Precisely, the states of Chiapas and Yucatan have registered the highest rate of forest conversion to grasslands and slash-and-burn cultivation over the past two decades, and Chiapas alone has contributed towards 12% of national deforestation during the period 1993-2007 (De Jong et al, 2010; Díaz-Gallegos et al., 2010).

In Mexico, deforestation occurs because forests become converted to agriculture, livestock and urban areas. But also because logging activities fail to meet the requirements of forest management plans. All these processes result in the loss of forest goods and services (Lambin et al. 2003), and they contribute to ecosystem fragmentation (Ochoa-Gaona & González Espinosa, 2000; Cayuela et al., 2006), biological invasions (Hobbs, 2000), greenhouse gas emissions (Watson et al., 2000), biodiversity loss (Lugo et al., 1993), soil degradation (Lal, 2004) and water siltation (Sweeney et al., 2004).

Deforestation is one of the key contributors to greenhouse gas (GHG) concentrations in the atmosphere (IPCC, 2000; Canadell & Raupach, 2008). Between 2003 and 2008, GHG deforestation-related emissions in Chiapas were estimated to be 16,477 (±7,299) Gg CO_2/year, while 414 Gg CO_2–eq were attributed to forest fires during the same period. These emissions represent 23.5% of national land-use change related emissions over the same period (Gobierno del Estado de Chiapas, 2011). In Chiapas, deforestation processes have affected highland, cloud and tropical forests. These forests have decreased in favour of agriculture, pastures and secondary vegetation. The original areas of some of these forest types have been reduced by 50% (de Jong et al, 2010). In particular, tropical mountain cloud forests and mangroves have been threatened by commercial agriculture, and considerable endemic biodiversity has subsequently been lost (Hirales-Cota, 2010; Toledo-Aceves et al., 2011). The Selva Lacandona (Lacandon rainforest) is located in the southern region of the country next to Guatemala, and it has been severely deforested during the last 40 years. The rainforest area of *Marques de Comillas* lost 81,080 ha of tropical forests between 1986 and 2005, which represents 48% of the original forest cover (Castillo-Santiago 2009).

Deforestation and degradation have occurred despite the fact that a variety of policy tools and approaches have been developed by national and regional governments, as well as by civil organisations, in order to guarantee forest and biodiversity conservation, including people-oriented conservation areas; community-based sustainable resource use management approaches; technological innovations for improved forest and agricultural management practices; and payments for ecosystem services (PES) (Deininger & Minten, 1999; Corbera, 2005; Cayuela et al, 2006). It is recognised that managed forests and agroforestry systems can contribute to conserve soil, regulate water flows, support biodiversity and sequester significant amounts of carbon by including timber-focused trees for durable products. Some of these land management systems can maintain biomass for longer, restore site capacity and increase economic benefits compared to a business-as-usual scenario (Kotto-Same et al., 1997; De Jong et al., 2000; Albrecht & Kandji, 2003; Montagnini & Nair, 2004; Soto-Pinto et al., 2010). The evidence presented before, however, has demonstrated that most of these policy and project-based approaches have been far from successful, and have been unable to halt land-use change in the region as a whole. There are of course apparently successful experiences, which should help us to learn lessons and identify avenues for improving the design and effectiveness of existing policies and instruments. One of these, institutional development, aims to encourage and facilitate local inputs and experimentation, interaction and consultation of local actors among themselves and to interact with relevant external agents to increase opportunities for the poor; it has a crucial importance in territorial development (Evans, 2004; Schejtman and Berdegué, 2004).

One of the latter experiences concerns the project being analysed in this chapter, which has been promoting agroforestry, reforestation and conservation activities for offsetting GHG emissions since 1994. The Scolel Té project has allowed carbon offsets to be sold through the voluntary market and will provide non-timber and timber products in the short, medium and long term. In the following sections, we examine the involvement in the project of three municipalities located in the northern-eastern tropical area of Chiapas, Mexico (i.e., Marqués de Comillas, Chilón and Salto de Agua) (Figure 1), and we discuss the potential of alternatives of avoided deforestation and agroforestry systems as well as institutional arrangements resulting from project development in these municipalities. The following section of the chapter describes the process of deforestation in Marqués de Comillas, a representative area of the state's ongoing deforestation and degradation processes. The central part of the chapter highlights Scolel Te's conservation and forest management approach in our selected municipalities, and it discusses the drivers and constraints for the successful realisation of environmental, economic and social benefits in the three selected cases. The last part of the chapter discusses the overall results in the context of evolving carbon forestry markets and the through the enhancement, conservation and sustainable management of forest stocks.

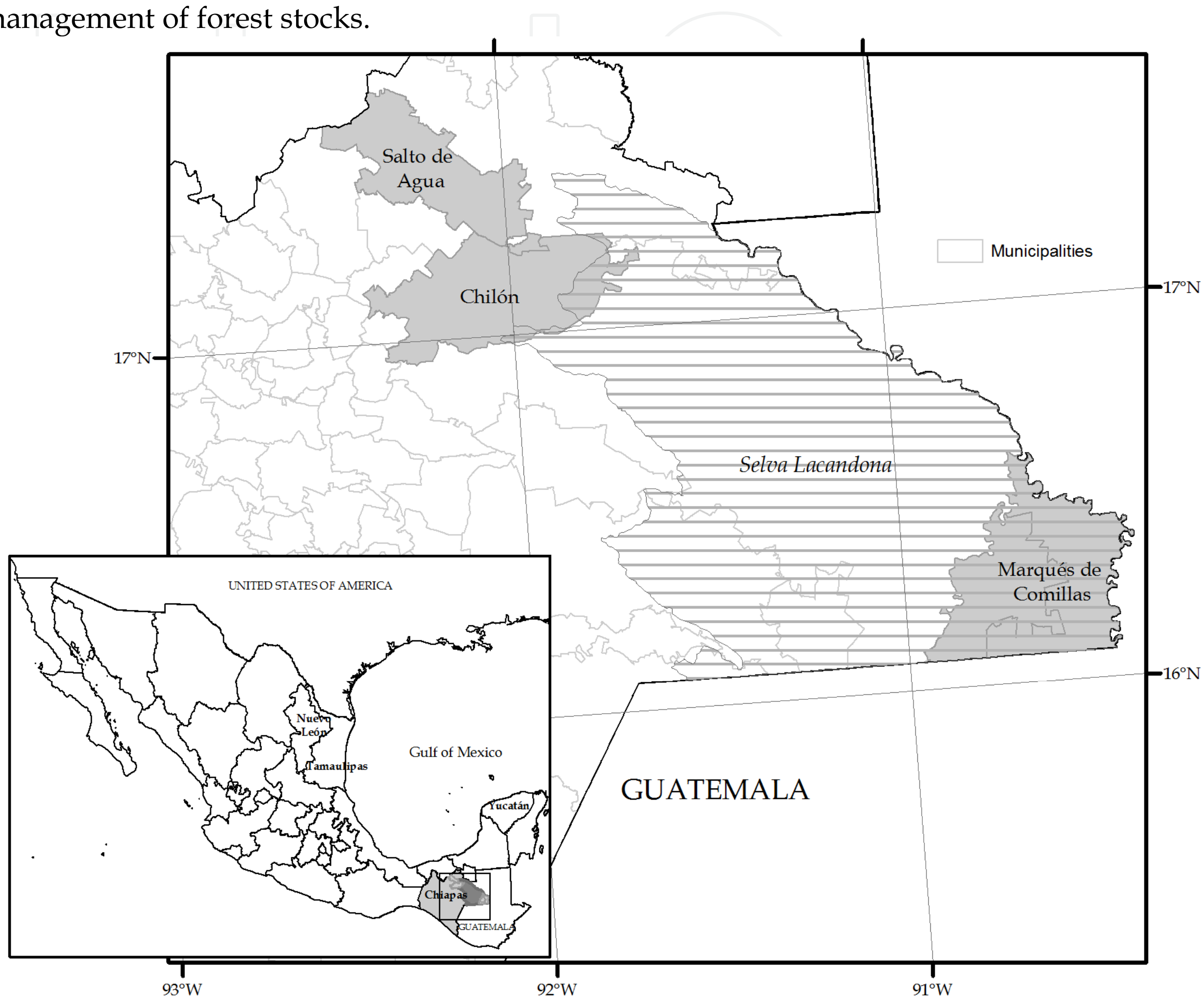

Fig. 1. Study area in Chiapas, Mexico.

2. The process of deforestation in Marqués de Comillas

Marqués de Comillas is one of the four municipalities of La Selva Lacandona and it comprises a total area of 203,200 ha. In the last few four decades, this municipality showed one of the highest deforestation rates in Mexico. Between 1986 and 2005 it lost approximately 81,080 ha of tropical rainforest, which represents 48% of its original forest cover (Figure 2). This loss contributed to 1.5% of the total CO_2 emissions from land use change in Mexico (Castillo-Santiago 2009).

Settlements in La Selva Lacandona were promoted during 1970-1980, and they have been recognised as the main driver of deforestation in Marqués de Comillas. Population was relocated to resolve conflicts of land scarcity and social rebellion in other Mexican states. Consequently, land in Marques de Comillas, which was completely forested at the beginning of the 1970s, was distributed in 37 ejidos[1] (Mariaca, 2002). The colonisation process was complemented by the construction of a main road, which allowed people and goods to flow between rural areas and the main cities of Tabasco and Chiapas (Harvey, 1998). Additionally, public policy favoured land use change from forest to maize agriculture, thereby financing deforestation in the 1970s. The process began with forest logging, followed by the use of fire for the cultivation of maize during three or four years. Once fertility was decreased and the land was weeded, due to intense cultivation, the natural steps were to intensify land use, fallow the land or let the grasses grow. Importantly, forested land was considered "idle land", and the process of deforestation was actually funded by government programs that encouraged cattle ranching. In 1978, the protected area of Montes Azules was established adjacent to Marques de Comillas, covering and area of 331,200 ha.

Subsequently, from 1992 to 1998, in Selva Lacandona six protected areas were established, five of them managed by the State, and other communal, with a total area of 123.660 ha: Chankin Protected Area (12.184 ha), Bonampak Natural Monument (4.357 ha), Biosphere Reserve Lacan-Tun (61.873 ha), areas of wildlife protection Nahá (3.847 ha), Metzabok (3.368 ha), Natural Monument Yaxchilan (2.621 ha), and by agreement of the Lacandon Community, the Communal Reserve of Sierra Cojolita with 35.410 ha (INE 2000).

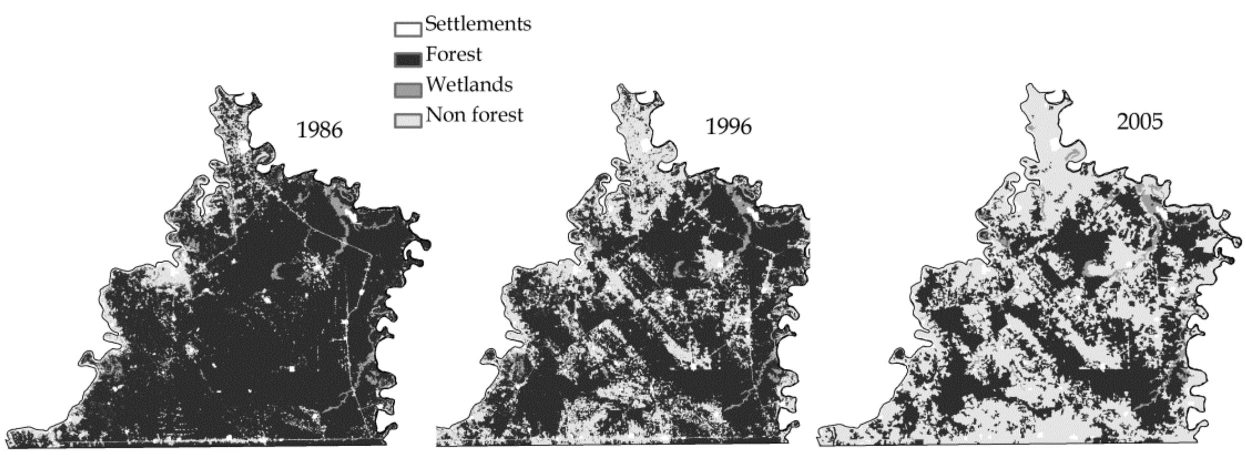

Fig. 2. Land-use changes from 1986 to 2005 in Marques de Comillas Chiapas, México.

In Marqués de Comillas, crops, such as cardamom, cocoa, rice, vanilla and rubber, were promoted by public and private investments to diversify the agricultural system and to employ local people who mainly participated as labourers in the 1980s and 1990s. Most of these projects were unsuccessful, due to their continuous requirements of external inputs, particularly technical support and capital. Forest initiatives were discouraging as well. In 1996, the Pilot Forest Plan was launched to promote timber extraction and establish the basis for a rational use of community forests. However, only few ejidos have maintained the deforestation rate under the regional average. More recently, other public initiatives have favoured the growth of oil palm for biofuels, which are rapidly growing in this

[1]Ejido is a particular form of land tenure in which the State has given the land to a group of people called "ejidatarios". The general use of forest and water is regulated by federal laws; land sale and use are decisions of the owner, this last is locally monitored and regulated by The Public Assembly of the community.

municipality, even at the expense of forests. Livestock has also gained ground. Livestock has very often represented the best economic option from the farmers' point of view because it has a relatively stable national market and a low level of investment is required. Livestock is thus still the dominant activity in the area and it occupies most of the landscape in Marques de Comillas at present (Table 1).

Type of vegetation	Area (ha)	Percentage
Tropical rainforest	69,360	34
Riparian forest	3,054	1
Wetlands	3,387	2
Secondary forest	16,544	8
Secondary vegetation (shrubs and herbaceous lands)	25,904	13
Pastures for livestock	56,339	28
Rainfed agriculture	24,324	12
Human settlements	2,404	1
Rivers	3,124	2
Total	204,440	100

Source: Castillo-Santiago, 2009

Table 1. Land use in Marqués de Comillas (Chiapas, México).

Livestock in Selva Lacandona has normally been characterised by its extensiveness, and it has been devoted mainly to grow calves that are fed with naturalised grasses of low nutritional value. Moreover, it has been characterised as having a low management level, high number of animals per land unity, low capital investments, poor infrastructure, scarce technical assistance and scarce financial support (Jiménez et al, 2008; Martínez & Ruiz de Oña, 2010). Table 2 shows the main features of the livestock system in communities of Selva Lacandona. Most of the farmers (95%) have designed their systems to produce calves to sell them to intermediaries in the local and regional markets. The trees located in the pastures are mainly tropical forest remnant trees tolerated for shading cattle, including *Blephariduim guatemalensis*, *Sabal mauritiformis, Vatairea lundellii, Guarea glabra, Albizia adinocephala, Bursera simaruba, Spondias mombin,* and *Swietenia macrophylla.* Specific timber species, such as "popiste" (*B. mexicanum*) and guanacastle (*Enterolobium cyclocarpum*), are sometimes favoured with the purpose of being used as a lumber source in rural construction (local market or self-supply).

Recently, several studies have highlighted the importance of silvopastoral systems and other agroforestry systems for conserving biodiversity and connecting countryside landscape with reserves (Harvey et al, 2006; Rice & Greenberg, 2004). Several institutions, including the Commission for Natural Protected Areas (CONANP), the Mesoamerican Biological Corridor (CBM) and the National Commission of Knowledge and Use of Diversity (CONABIO) have launched programs in Selva Lacandona, specifically in Marques de Comillas, to improve rural production and promote conservation. One of these initiatives is the Scolel Te' project, which began in 1994 as a pilot experience in Chiapas and it is managed by the local organisation AMBIO cooperative. It originally involved a few dozens of farmers in the central highlands of the state and it has now grown to encompass more than 700 participants and their families (3500 beneficiaries) in approximately 50 communities of Chiapas and the neighbouring states of Oaxaca and Tabasco. The project is built on a

Characteristics of livestock production units	**La Siria, Ocosingo**	**Ach lum Monte Libano, Ocosingo**	**Amatitlan, Maravilla Tenejapa**	**La Corona, Marques de Comillas**
Land use type	Ejido	Ejido	Ejido	Ejido
Ethnic group	Tseltal	Tseltal	Chol and Mestizo	Mestizo
Altitude (m a.s.l.)	150-200	300 - 500	275 - 590	75 – 125
Land use	Maize agriculture, Fruits, Livestock Forestry	Maize agriculture Livestock	Maize agriculture Livestock Forestry	Maize agriculture Livestock Forestry PES-Carbon
Average land area (ha/family)	15	20	10	45
Pasture area for cattle grazing (ha)	10	15	5	25
Stocking rate AU/ha	1.9	2.1	1.5	2.7
Management system	Livestock with improved pastures (*Brachiaria brizantha, B humidicola*). Rotations without technical assistance No supplement.	Livestock with native grasses and "estrella" grass (*Cynodon niemufensis*). Without technical assistance and financial support. Breeding and sales of young calves	Livestock with forest fallow grazing, and crop residues (maize stubbles)	Livestock on pastures with dispersed trees, live fences, and pastures with forest patches. Improved pastures (*B. decumbens, B. humidicola, Andropogon gayanus*). Growing and sale of calves recently wean
Product destination (mainly meat)	Local market consumption	Local market consumption	Local market consumption	Local and regional market consumption
Forage trees on pasture grazing areas	*G. sepium, Parmentiera aculeata, Brosimum allicastrum, Guazuma ulmifolia, Leucaena leuucocephala*	*Whiteringia meiantha, Thitonia diversifolia, G. sepium, G. ulmifolia, Eupatorium morifolium*	*G. ulmifolia, Diphysa americana, Spondias mombin, Bahuinia herrerae*	*G. sepium, Cecropia obtusifolia, Erythrina sp, L. leucocephala, P. aculeata*

Table 2. Socio-technical characteristics of livestock in four communities in Selva Lacandona (Chiapas, México).

participatory method that identifies rural development and forest management opportunities and constraints of each involved farmer and community. Subsequently, it helps farmers and communities to select and establish trees on individual or collective lands according to their preferences, providing technical support and paying participants for the provision of carbon offsets to national and mostly international buyers (Corbera 2010; Ruiz de Oña, 2011). Over time, the project has become a global landmark for the development of community-based payments for ecosystem services, and it has created its own design and implementation standard (www.planvivo.org). This approach has been extended to other similar projects in Uganda, Mozambique, Malawi and Cameroon

3. Avoiding deforestation in La Corona, Marqués de Comillas

In Ejido La Corona, a previous study estimated that 305 ha of forested land would have to be lost for agriculture purposes, as a baseline scenario during the period 2004-2009 (Quechulpa, et al., 2010). With the support of the AMBIO cooperative and financial support from Pro-Árbol (i.e., a governmental PES program developed by Mexico's National Forest Commission (CONAFOR) a participatory planning method was developed to design interventions for avoiding deforestation and increasing tree cover in deforested land. Concurrent financial resources were allocated from several programs, including Scolel Te, the Mexican Fund for Nature Conservation (FMCN) and Mesoamerican Biological Corridor (CBM). Financial resources were aimed to reduce pressure on forest land to avoid land-use change and to intensify cattle raising activities.

The following two approaches were suggested by community members and selected for project development: 1) management of secondary vegetation and forest conservation and 2) establishment of agrosilvopastoral and agroforestry systems in open and grazing areas. As a result, secondary vegetation was managed by pruning and thinning trees to eliminate competition and favour growth of the most commercially valuable species. Activities for forest conservation included the opening and maintenance of 22 km of fire protection rifts, acquiring equipment for fires, combating brigades trained for fire control, supervising and regulating agricultural burns. Communal forest conservation incorporated a wider vision of the territory and collective agreements related to resource access into the working plan, thereby establishing rules and monitoring to regulate land use change according to the plan.

The establishment of 45.5 km of live fences was carried out in accordance to the work plan (Figure 3) using "cocoite" forage trees (*G. sepium*) and other timber species, such as *Tabebuia rosea*, *T. guayacan*, *C. odorata*, *S. macrophylla* and *Pachira aquatica*. All forage trees were native species produced in communal nurseries. Other activities included the use of forage grasses such as *Brachiaria*, the promotion of cattle-feed supplements with multi-nutritional blocks, improvement of cattle breeds, establishment of livestock infrastructure, establishment of technical training and creation of a farmer-to-farmer exchange system (Ambio Cooperative, 2010). In parallel, other projects particularly targeted towards women, such as the substitution of traditional open stoves by fuel wood-saving stoves, improvement of house conditions and improvement of other communal infrastructure, were also launched.

In the first five years of the project, all of these activities resulted in 179 ha of prevented deforestation out of the 305 ha previously estimated to be lost, which translated in reduced CO_2 emissions from land-use change. According to inventories from permanent plots, 407 ha of passively restored secondary forests accumulated biomass with a rate of 4.4 ton ha^{-1} $year^{-1}$

(approximately 3000 ton of CO_2 per year), and it was estimated that the establishment of live fences fixed approximately 3200 tonnes of CO_2. Other intangible benefits included the organisation of farmers for fire prevention; the organisation and training of brigades for carrying out forest inventories; and the improvement of productive systems. Above all, the recognition that forests may contribute to environmental and socioeconomic direct benefits was one of the main gains resulting from the project.

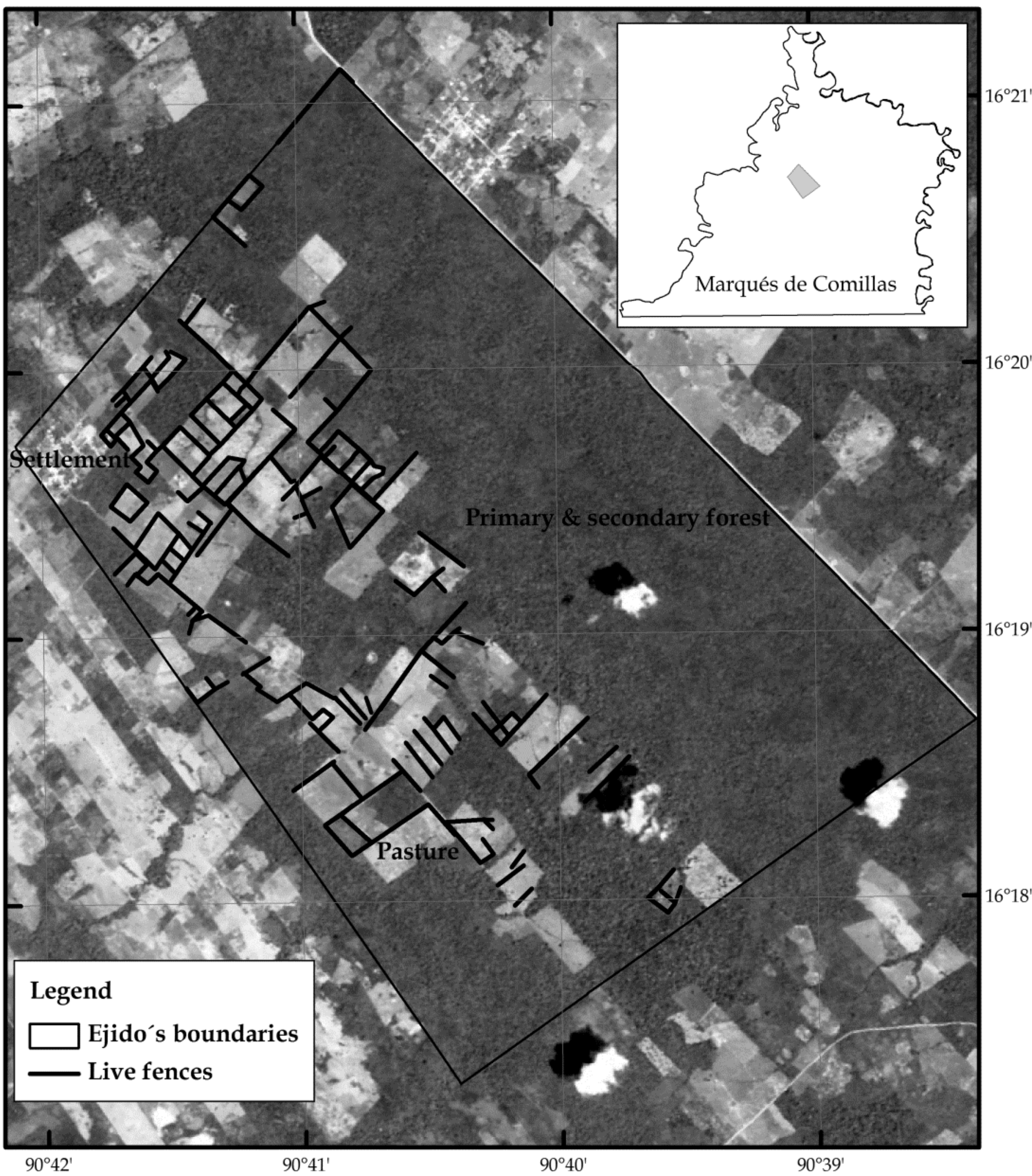

Fig. 3. Participatory planning for designing forestry and agroforestry interventions in La Corona and Marques de Comillas in Chiapas, Mexico.

As a result of this management, Ejido La Corona, with a total area of 2254 ha, conserves 68% of the total rain forest (1530 ha), which includes primary and old secondary tropical rain forests. Nonetheless, livestock (528 ha), agriculture (177 ha) and urbanisation (20 ha) coexist with forests and the biological reserve, and these combined areas support 292 people (Quechulpa 2010).

Subsequent studies have evaluated the performance of the systems established by producers in La Corona. An example is shown in Table 3, where the carbon components of pastures with and without trees are presented.

Carbon components	Pasture in monoculture	Pasture with live fences	Pasture with dispersed trees
Trees (Mg C ha^{-1})	0.00	7.6	4.23
Herbs (including grasses Mg C ha^{-1})	1.33	0.91	0.64
Total roots (fine and coarse Mg C ha^{-1})	0.66	1.88	1.12
Live biomass (Mg C ha^{-1})	1.99	10.4	5.99
Soil organic matter 0-40cm (Mg C ha^{-1})	60.62	66.68	76.89
Total carbon (Mg C ha^{-1})	64.62	87.5	88.89

Source: modified from Aguilar-Argüello, 2007.

Table 3. Carbon stocks in different components of monoculture pastures, live fences and dispersed trees in pastures in La Corona and Reforma Agraria in Chiapas (Mg C ha^{-1}).

4. Agroforestry in Chilón and Salto de Agua, Chiapas

Study communities of these municipalities are located in Chiapas tropical zone. Salto de Agua is located approximately 200 m a.s.l., and it has a warm and humid climate. In addition, Salto de Agua has a tropical rainforest. Meanwhile, Chilón is located in the intermediate tropical zone between 700 and 900 m a.s.l. It has a warm climate and abundant summer rains. Chilón has also a tropical rainforest, and the main soil types in this area are Regosols, Leptosols, and Cambisols (INEGI 1984; Soto-Pinto et al., 2010). Land is devoted mainly to agriculture, which is based on maize cultivation in both municipalities. While in Salto de Agua, maize cultivation is the key commercial and subsistence crop, Chilón farmers cultivate coffee as the main source of income. In both "ejidos", farmers organise around small activity groups for establishing agroforestry systems. In Chilón, farmers established maize associated to trees (Taungya rotational systems), improved fallows and shaded coffee systems; while farmers in Salto de Agua established taungya systems converted finally to silvopastoral systems. Improved fallow consists of enriching fallow lands with secondary vegetation with timber trees, so far as the latter are planted during the first five years of the fallow period. Taungya, in turn, consists of enriching maize cultivated plots with timber trees in a rotational pattern; and coffee systems were enriched with timber trees in association to other variety of previously existing native trees as shading cover. The project Scolel Té has contributed to organizing agroforestry practices, training and monitoring.

Previous evaluations by El Colegio de la Frontera Sur (ECOSUR) have shown that agroforestry systems provide multiple environmental services and can increase productivity, land and labour worth in relation to conventional land uses, such as extensive cattle farming and maize crops without trees (Soto-Pinto et al, 2010; Soto-Pinto, submitted). Coffee cultivation under the shade of trees conserves at least 40% of the total woody plant diversity in scarce neighbouring forests (Soto-Pinto et al, 2000; Romero-Alvarado et al, 2002; Peeters et al, 2003). Organic coffee cultivation translates into a higher carbon content in the upper soil layer (0-30 cm) than non-organic coffee systems, being able to store between 129.8 and 215.6 Mg C ha^{-1} in their components, including soil C (Soto-Pinto et al., 2010). However, the amount of aboveground biomass depends on the structure and composition of shade vegetation (Table 4). Economic analyses comparing conventional coffee with and without enrichment of timber trees and PES and organic coffee with timber trees and PES have shown positive benefit/cost ratios, as follows: 0.8, 1.2 and 1.8 for conventional management, conventional management enriched with timber trees, and organic coffee plus carbon sequestration and timber, respectively (Table 5).

Carbon components	Natural traditional polyculture coffee	Natural traditional polyculture coffee enriched with timber trees	Organic traditional polyculture coffee enriched with timber trees
Adult trees (≥10cm)	17.02±3.32	27.3±4.79	37.89±5.17
Tree saplings (<10cm)	0.14±0.05	0.36±0.14	0.85±0.26
Coffee shrubs (Mg C ha^{-1})	11.37±1.56	11.03±2.25	8.83±1.30
Herbs (Mg C ha^{-1})	0.44±0.09	0.122±0.03	0.24±0.07
Fallen tree branches (Mg C ha^{-1})	6.16±0.58	8.03±1.1	9.67±1.08
Live biomass (Mg C ha^{-1})	35.13±3.57	46.84±7.1	57.47±7.13
Roots (Mg C ha^{-1})	1.47±0.79	0.67±0.13	0.33±0.07
Litter (Mg C ha^{-1})	5.24±0.88	5.6±1.09	5.72±0.91
Dead organic matter (Mg C ha^{-1})	6.71±1.29	6.27±1.09	6.0±0.85
Soil organic matter (Mg C ha^{-1})	87.96±12.55	117.35±	152.12±10.26
Total Carbon (Mg C ha^{-1})	129.8±15.69	170.46±	215.64±12.16

Source: modified from Aguirre, 2006

Table 4. Carbon components in three types of coffee systems in Northern Chiapas (Mexico).

Indicator	Natural polyculture coffee	Natural polyculture coffee enriched with timber trees	Organic polyculture coffee enriched with timber trees
Current costs (USD)	105.87	129.83	204.42
Current benefits (USD)	87.33	263.1	384.34
Net present value (USD)	- 18.55	133.25	179.94
Annual net present value	- 927	6.66	8.99
Cost-benefit	0.8	2.0	1.9
Internal rate of return (%)		15.2	19.4

Source: modified from Aguirre, 2006

Table 5. Economic evaluation for three scenarios of coffee farms: natural polyculture coffee, natural polyculture enriched with timber trees and organic polyculture enriched with timber trees in Northern Chiapas, Mexico.

Improved fallows have demonstrated to be an adequate alternative to slash-and-burn agriculture, due to their capacity to increase biomass, productivity, economic value, complexity, carbon and diversity (Roncal 2007; Soto-Pinto et al., submitted). Tables 6 and 7 show structural and functional variables of these systems in the region. Results of these evaluations show that these systems may contribute to sedentarise the maize system, increase economic value and avoid deforestation while diversifying non-timber and timber related products.

Both systems have shown their multifunctionality for improving productivity and restoring site features, environmental conditions and livelihood conditions (Soto-Pinto et al., Submitted).

Land use systems	Adult tree density (trees ha-1)	Tree sapling density (100m2)	Tree Height (m)	Tree Diameter (cm)
Taungya system 9-13years	520±218	31.9±19.0	8.8±1.4	16.2±3.9
Improved Fallow at 9th year	623.3±106.3	4800±2361.0	8.26±1.3	16.88±3.16
Traditional Fallow >30 years	463.8±191.8	3616.7±2700	7.4±1.3	17.7±3.47
Inga-shaded organic coffee >10 years	79.3±79.3	25.1±7.5	5.6±1.0	19.2±13.0
Polyculture-shaded organic coffee >10 years	115.0±115.0	22.8±6.9	7.3±4.1	15.0±9.9
Polyculture-shaded non organic coffee >10 years	206.3±180.0	21.5±7.5	6.5±3.5	15.4±10.2
Pasture with dispersed trees >10 years	20.0±10.0	112.0±16.0	6.1±3.4	14.8±4.5
Pasture with live fences >10 years	56.0±37.3	116.0±68.7	4.5±1.5	10.3±4.5
Pasture in monoculture >10 years	0	0	0	0
Continuous maize 4-7 years	210.0±217.0	66.6±57.7	2.1±0.42	7.17±2.2

Source: Aguilar-Argüello 2007; Roncal –García et al., 2007; Aguirre 2006; Soto-Pinto et al. 2010; Soto-Pinto et al. submitted; and other original data

Table 6. Structural variables of agroforestry systems in Selva Lacandona (Mexico).

In Salto de Agua and Chilón the decisions on land use are taken individually, often under the consensus of the family and the work group. The impact seems to be centered at the plot level. However the impact on the territory has not been evaluated.

In each community, regional and local technicians act as training guides. Local decisions are taken individually or by group. Regional and state-level assemblies of technicians discuss, analyse problems, and propose solutions, new projects and financial supports to resolve specific problems. Civil and academic organizations and government dependencies accompany the process offering punctual technical assistance to resolve specific questions and financial support. Academy plays an important role in knowledge management, offering training and developing human resources. All of the sectors are involved in thematic networks contributing to the building of a public policy in the thematic of forestry programs, PES and territorial developing, among other issues.

Land use systems	Aboveground tree biomass (Mg ha-1)	Soil Carbon 0-30cm in depth (Mg C ha-1)	Tree Species Richness (number of species)
Taungya system 9-13years	44.4±25.7	104.7±30.1	3.4±2.3 (500m^2)
Improved Fallow at 9th year	164.3±65.4	88.85±4.7	15.8±3.9 (1000m^2)
Traditional Fallow >30 years	109.35±66.7	120.4±7.0	19.7±3.8 (1000m^2)
Inga-shaded organic coffee >10 years	34.1±17.6	75.83±28.6	5.6±2.9 (1000m2)
Polyculture-shaded organic coffee >10 years	75.8±27.4	131.13±23.4	15.7±3.3 (1000m2)
Polyculture-shaded non organic coffee >10 years	54.6±25.9	101.13±27.9	8.0±3.3 (1000m2)
Pasture with dispersed trees >10 years	8.5±6.0	46.4±13.0	2.6±2.6
Pasture with live fences >10 years	15.2±10.7	40.5±9.8	1±0
Pasture in monoculture >10 years	0	50.2±14.6	0
Continuous maize 4-7 years	4.38±3.62	115.0±12.3	14.0±4.8 (1000m2)

Source: Aguilar-Argüello 2007; Roncal –García et al., 2007; Aguirre 2006; Soto-Pinto et al. 2010; Soto-Pinto et al. submitted; and other original data

Table 7. Functional variables of agroforestry systems in Selva Lacandona (Chiapas).

5. Discussion

In some places traditional communities have managed their resources sustainably for long time, even better than in many protected areas managed by the State, especially in Latin America (Bray et al., 2008; Porter-Bolland, et al., In Press). However, in the last years the effects of public policy, colonization process and urban development, among other land use change drivers led to high deforestation rates in sites which until four decades before were completely forested, this is the case of Selva Lacandona in Mexico where Marques de Comillas is a referent.

Enriched shaded coffee, alternative rotational and silvopastoral systems have demonstrated benefits in the topics of food production, biodiversity and economy of livelihoods. Results demonstrate the value of agroforestry systems as a potential strategy for tree cover recovery and carbon sequestration (Haile et al., 2008; Nair et al., 2010; Soto-Pinto et al., 2010) and suggest that adequate planning, incentives and capacity-building efforts can lead to better conservation practices (Berkes, 2007). In Ejidos La Corona and communities in Chilón and Salto de Agua people have improved their local organisational activities, either in groups or collectively through preventing deforestation; intensifying the agriculture process; reforesting the deforested and open areas; controlling fire; acquiring new abilities; creating norms, sanctions, work plans, and social rearrangements; and reinforcing old capacities for developing a forest culture as a part of a new institutional development and good governance (Evans 2004; Corbera, 2005, 2010). All this, coupled with the accompaniment of the civil society and academic institutions, and the involvement of government in a network of ecosystem services has been key in order to begin a governance development (Ruiz de Oña et al., 2011). However, the scaling up of this process is a challenge since it represents a greater organizational complexity and negotiation, a matter of governance (Swiderska et al., 2008).

In Marques de Comillas collective organization and decisions can impact broad and decisively on the territory in the short term, while in Chilón and Salto de Agua decisions taken by individuals or groups may be slower than collective decisions. Future studies on social resilience on both types of patterns should be of great importance. The lesson gained in this experience is that public programs must consider community priorities based on an integral regional vision, environmental education, strengthening of local capabilities and organisation. As a whole, public priorities may be a better appropriation and adaptation of programs in a new model of territorial development by considering institutional arrangements (Merino and Warnholtz, 2005). Farmers are the leading experts regarding their context and livelihood conditions and may or may not adopt and adapt programs that involve a territorial vision. The intense participation of communities may allow better monitoring, especially when these programs are integrated into their own community-management plans (Franzel and Scherr, 2002).

Territorial participatory planning of agroforestry and restoration systems, in addition to the institutional development have demonstrated their capacity to benefit environment, farmer's livelihoods and social capital, through their contribution to increase productivity, complexity, diversity, economic value, organization capacities and knowledge, which as a whole may contribute to avoid deforestation (Alburquerque, 2002; Bray, 2008; Swiderska et al., 2008). However, other products, service, process and management innovations are required to have a broader menu of options for farming systems and livelihoods to ensure the permanence of forest systems in a competitive context. Some of the needs to be resolved in order to conceive this process as a territorial development are: the best practices to achieve food self-sufficiency, development of market chains, education, training, infrastructure, financial support, policy arrangements and skills of competitiveness for production systems (Alburquerque, 2002; Ruiz de Oña et al., 2011). An integration of an agroecological matrix which enables agricultural production and natural resource conservation and a new political vision may help facilitate social and environmental synergies in rural areas (Perfecto and Vandermeer, 2010)

Although the experience run by the project Scolel te' in Marqués de Comillas is not precisely REDD+, may offer a set of lessons learned about the conditions required for a good management for reducing deforestation. Some elements which need to be considered in order to contribute to the design of PES programs are the following: 1) technology adaptation, 2) ordering of land use with a territorial development vision, 3) broad participation of all stakeholders, 4) institutional development at local, regional levels and, 5) involvement in networks to launch processes of governance for the management of an adequate public policy of PES. Although these systems may contribute to avoiding deforestation, their potential to become part of REDD programs need to be better discussed since the relationship among markets and actors' rights and duties, in addition to the uncertainty regarding the factors influencing effectiveness on deforestation is unclear (Coad et al., 2008).

In Chiapas, a process of institutional development around the issue of PES is emerging. In the last years groups working on ecosystem services (State Group of Ecosystem Services, GESE by its acronyms in Spanish) and deforestation and degradation (REDD) have matured in the state of Chiapas; representatives of the "Camara de Diputados y Senadores del Estado de Chiapas" (State House of Representatives and Senate) have approved the Law for Mitigation and Adaptation to Climate Change in the State; meanwhile, a group of research institutions and organizations of the civil society carry out an effort of monitoring, reporting and verification

(MRV) in rural communities as a basis for a REDD planning in Chiapas. Moreover, the Government of the States of Chiapas and Campeche has recently signed an agreement with Acre Brazil and the Government of California through The Governors' Climate and Forests Task Force (GCF) for REDD + (http://tropicalforestgroup.blogspot.com/2010/11/text-of-ca-chiapas-acre-mou-on-redd.html) with the aim to "developing a common subnational REDD+ framework or patform for adoption and implementtion in GCF states and provinces" and "to building databases, developing options for linkage arrangements for getting financial support, technical assistance, capacity building, and advancing stakeholder involvement" (http://www.gcftaskforce.org). For its part, the Chiapas Government has allocated funds from the vehicle ownership tax payment to farmers focused on a Biodiversity Hotspot, the Selva Lacandona (Lacandon Community). This region has been widely supported by conservation projects, but from the point of view of other authors it lacks of organizational conditions for effective management of forest carbon (Castillo-Santiago et al 2009).

At the national level, CONAFOR (Forestry National Comission) has convened a technical advisory board (Consejo Tecnico Consultivo CTC) aimed to "promote and deliver recommendations to the government institutions in order to influence the building of a functional mechanism for designing and implementing REDD+ in Mexico, guarantig the transference and maximization of environmental and social benefits" (http://www.reddmexico.org). However, groups of civil society organizations drew attention to the topic of indigenous peoples' rights. Hence, much effort is still needed to really get to have a shared vision.

Forest alternatives will only be adopted by farmers if they respond to expressed needs of population, reduce risks, alleviate constraints, and increase productivity. Deforestation process seems to take its course if drivers persist (Cortina et al., in press). Farmers will be interested since they participate and design innovations from the beginning of the project and also if the initiatives constitute a good deal from the set of alternatives offered in the territory (Franzel & Scherr, 2002; Merino & Warnholtz, 2005; Bray, 2008). Mere academic exercises of land use ordering may be at risk of abandonment if local priorities are left out, so that the participation of farmers (men and women) in planning, designing and applying technology, norms, rules and sanctions among other local institutions must be established with broad participation of all of the actors involved.

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7. References

Aguilar-Argüello V.H. (2007). Almacenamiento de carbono en sistemas de pasturas en monocultivo y silvopastoriles, en dos comunidades de la Selva Lacandona, Chiapas, México. MSc Thesis. Universidad Autónoma Chapingo. Centro de Agroforestería para el Desarrollo Sustentable, Chapingo Edo. Mexico, 89p.

Aguirre D.C.M. (2006). Servicios ambientales: Captura de carbono en sistemas de café bajo sombra en Chiapas, México. MSc Thesis. Universidad Autónoma Chapingo. Centro de Agroforestería para el Desarrollo Sustentable, Chapingo Edo. Mexico, 84p.

Albrecht A., S.T. Kandji. (2003). Carbon sequestration in tropical agroforestry systems. Agriculture, Ecosystems and Environment 99: 15–27.

Alburquerque L.F. (2002). Guia para agentes. Desarrollo economico territorial. Instituto de Desarrollo Regional. Fundación Universitaria. Sevilla Spain, 214 p.

Berkes F. 2007. Community-based conservation in a globalized world. PNAS 104 (39): 15188-15193.

Bocco G., M. Mendoza, O. Masera. (2001). La dinámica del cambio de uso del suelo en Michoacán. Una propuesta metodológica para el estudio de los procesos de deforestación. Investigaciones Geográficas. Boletín del Instituto de Geografía de la UNAM 44:18-38.

Bray D.B., E. Duran, V.H. Ramos, J.F. Mas, A. Velazquez, R.B. McNab, D. Barry, J. racachowsky. 2008. Tropical deforestation, community forests, and protected áreas in the maya forests. Ecology and Society 13(2): 56

Canadell JG, Raupach MR (2008) Managing forests for climate change mitigation. Science 320(5882):1456–1457.

Castillo-Santiago, M.A., (2009). Análisis con imágenes satelitales de los recursos forestales en el trópico húmedo de Chiapas. Un estudio de caso en Marqués de Comillas. Tesis de doctorado en Ciencias Biológicas, Universidad Nacional Autónoma de México. 123 p.

Cayuela L., J. M. Benayas, C. Echeverria. (2006). Clearance and fragmentation of tropical montane forests in the Highlands of Chiapas, Mexico (1975–2000). Forest Ecology and Management 226, 208–218.

Coad, L., Campbell, A., Clark, S., Bolt, K., Roe, D., Miles, L. (2008). *Protecting the future: Carbon, forests, protected areas and locallivelihoods*. Revised May 2008. UNEP World Conservation Monitoring Centre, Cambridge, U.K.

Corbera E. (2005). Bringing development into carbon forestry markets: Challenges and outcomes of small-scale carbon forestry activities in Mexico. In: D. Murdiyarso y H. Herawati.pp. 42-56. Carbon forestry: ¿who will benefit? CIFOR (Center for Intnal. Forestry Res.), Bogor, Indonesia.

Corbera E. (2010). Mexico's PES-carbon programme: a preliminary assessment and impacts on rural livelihoods. In: L. Tacconi, S. Maharty and H. Sulch, 54-81pp. Payments for environmental services, forest conservation and climate change. Edmund Elgar, Cheltenham UK.

Cortina V.S., H. Plascencia, R. Vaca, G. Schroth, Y. Zepeda, L. Soto-Pinto. Resolving the conflict between ecosystem protection and land use in protected areas of the Sierra Madre de Chiapas, Mexico. Environmental Management. In Press.

de Jong B.H., Ochoa S, Cairns MA. (2000). Carbon flux and patterns of land-use/land-cover change in the Selva Lacandona, Mexico. Ambio 29(8):504–511.

de Jong B.H., V. Maldonado, F. Rojas G., M. Olguín A., V. de la Cruz A., F. Paz P., G. Jiménez Ferrer, M. A. Castillo-Santiago. (2010). Sector uso del suelo, cambio de uso de suelo y silvicultura del inventario estatal de gases de efecto invernadero del Estado de Chiapas. Gobierno del Estado de Chiapas. Tuxtla Gutiérrez, Chiapas México. 71p.

Deininger K.W., B. Minten. (1999). Poverty, Policies, and Deforestation: The Case of Mexico. Economic Development and Cultural Change, 47 (2):313-344.

Díaz-Gallegos J.R., J.F. Mas, A. Velázquez. (2010). Trends of tropical deforestation in Southeast Mexico. Singapore Journal of Tropical Geography, 31 (2): 180-196.

Echeverría C., L. Cayuela, R.H. Manson, D.A. Coomes, A. Lara, J.M. Rey-Benayas, A.C. Newton. (2007). Spatial and temporal patterns of forest loss and fragmentation in Mexico and Chile. In: A.C. Newton (Ed.) pp. 14-42. Biodiversity and conservation in fragmented forest landscapes. CABI, Oxford UK.

Evans P. (2004). Development as institutional change: the pitfalls of monocropping and the potentials of deliberation. Studies in Comparative International Development. 38 (4): 30-52.

FAO (2007). Paying Farmers for Environmental Services, Map 2, page 18. Rome.

FAO (2010). Global forest resources assessment. (2010). Main report. Food and Agriculture Organization of the United Nations. FAO Forestry Paper 163. Rome Italy, 340p.

Franzel S., S.J. Scherr. (2002). Trees on the farm. Assessing the adoption potential of agroforestry practices in Africa. CABI. New York, 185p.

Gobierno del Estado de Chiapas. (2011). Inventario de gases efecto invernadero del estado de Chiapas. http://www.cambioclimaticochiapas.org/portal/descargas/igei/resumen_igei.pdf

Haile S., P.K.R. nair, V.D. Nair. (2008). Carbon storage of different soil-size fractions in Florida silvopastoral systems. J. Environ. Qual. 37: 1789-1797

Harvey C.A., A. Medina, D. Merlos S., S. Vilchez, B. Hernández, J.C. Saez, J.M. Maes, F. Casnoves, F.L. Sinclair. (2006). Patterns of animal diversity in different forms of tree cover in agricultural landscapes. Ecological Applications 16 (5): 1986-1999.

Harvey, N. (1998). El fin del "desarrollo" en Marqués de Comillas: discurso y poder en el último rincón de la Selva lacandona. In: Reyes R., M.E., Moguel, R., y van der Haar, G. (cords.), Espacios disputados: transformaciones rurales en Chiapas, Universidad Autónoma Metropolitana y El Colegio de la Frontera Sur, México.

Hirales-Cota M., J. Espinoza-Avalos, B. Schmook, A. Ruiz-Luna, R. Ramos-Reyes. (2010). Drivers of mangrove deforestation in Mahahual-Xcalak, Quintana Roo, southeast Mexico Ciencias Marinas 36 (2):147-159.

Hobbs R.J. (2000). Land use changes and invassions. In Mooney H. A. and R.J. Hobbs (Eds.). Pp. 55-64. Invasive species in a changing world. Island Press, Washington DC.

INEGI (Instituto Nacional de Estadística, Geografía e informática). (1984.) Carta de uso del suelo y vegetación 1:25000. Maps E 15–8, E 15–11. Instituto Nacional de Estadística e Informática, Aguascalientes, México.

INE (Instituto Nacional de Ecología). 2000. Programa de manejo de la Reserva de la Biosfera Montes Azules. México. 256 p.

IPCC (Intergovernmental Panel for Climate Change). (2000). Intergovernmental Panel for Climate Change special report on land use, land-use change and forestry. Special Report. IPCC. Cambridge University Press, Cambridge, USA (http://www.grida.no/publications/other/ipcc_sr/).

Jiménez-Ferrer G., Aguilar AV., Soto-Pinto L. (2008). Livestock and carbon sequestration in the Lacandon rainforest, Chiapas México. In : Livestock and Global Climate Change. BSAS,Cambridge Press, UK, 195-197.

Klooster D. (2000). Beyond deforestation: the social context of forest change in two indigenous communities in Highland Mexico. Yearbook, Conference of Latin Americanists Geographers, 26: 47-59.

Kotto-Same J, Woomer PL, Appolinaire M, Louis Z. (1997). Carbon dynamics in slash-and-burn agriculture and land use alternatives of the humid forest zone in Cameroon. Agric Ecosyst Environ 65:245–256

Lal R. (2004). Soil carbon sequestration to mitigate climate change. Geoderma 123 (1-2): 1-22.

Lambin E.F., B. L. Turner, H. J. Geist, S. B. Agbola, A. Angelsen, J. W. Bruce, O. T. Coomes, R. Dirzo, G. Fischer, C. Folke, P. S. George, K. Homewood, J. Imbernon, R. Leemans, X. Li, E. F. Moran, M. Mortimore, P. S. Ramakrishnan, J. F. Richards, H. Skånes, W. Steffen, G. D. Stone, U. Svedin, T.A. Veldkamp, C. Vogel and J. Xu. (2001). The causes of land-use and land-cover change: moving beyond the myths. Global Environmental Change, Vol. 11 (4): 261-269.

Lugo E, J. A. Parrotta, S. Brown. (1993). Loss in species caused by tropical deforestation and their recovery through management. Ambio 22 (2/3): 106-109.

Maass S.F., H.H. Regil G., J. A. Ordoñez. (2006). Dinámica de población-recuperación de las zonas forestadas en el Parque Nacional Nevado de Toluca. Madera y Bosques 12(1):17-28

Mariaca, R. (2002). Marqués de Comillas, Chiapas: procesos de inmigración y adaptabilidad en el trópico cálido húmedo de México. Tesis de Doctorado en Antropología Social, Universidad Iberoamericana. 396 p.

Martínez M.P. y C. Ruiz de Oña P. (2010). Planeación comunitaria empleando la herramienta plan vivo. Consultancy Report to Corrredor Biológico Mesoamericano. San Cristóbal de las Casas, Chiapas, México 43p.

Merino-Pérez, L., G. Segura-Warnholtz. (2005). Las políticas forestales y de conservación y sus impactos en las comunidades forestales en México. In: Bray, D. B., L. Merino-Pérez, D. Barry (Eds), pp. 49-70. The Community forests of Mexico: managing for sustainable landscapes. University of Texas Press. Austin.

Montagnini F., P. K. R. Nair. (2004). Carbon sequestration: An underexploited environmental benefit of agroforestry systems. Agroforestry Systems 61: 281–295, 2004.

Nair P.K.R., V.D. Nair, B. M. Kumar, J.M. Showatter. 2010. Carbon sequestration in agroforestry systems. Advances in agrofomy 108:237-307.

Ochoa-Gaona, S., González-Espinosa, M. (2000). Land use and deforestation in the highlands of Chiapas, Mexico. Appl. Geogr. 20, 17–42.

Ortiz-Espejel B. y V.M. Toledo. (1998). Tendencias en la deforestación de la Selva Lacandona (Chiapas Mexico): el caso de Las Cañadas. Interciencia 23(6): 318-327.

Peeters l.Y.K, L. Soto-Pinto, H. Perales, G. Montoya, M. Ishiki. (2003). Coffee production, timber and firewood in Sothern México. Agric. Ecosyst. and Environmt 95 (2-3):481-493

Perfecto, I., J. Vandermeer. 2010. The agroecological matrix as alternative to the land-sparing/agriculture intensification model. PNAS 107 (13): 5786-5791.

Porter-Bolland L., E. A. Ellis, M. R. Guariguata, I-Ruiz-Mallén, S. Negrete-yankelevich, V. Reyes-García. 2011. Community managed forest and forest protected areas: an assesment of their conservation effectiveness across the tropics. Forest Ecology and Management. In Press.

Quechulpa, S., Castillo-Santiago, M.A., Esquivel, E., Hernández, M.A., Trujillo, J.M. (2010). Captura y reducción de emisiones de bióxido de carbono en el ejido La Corona, municipio de Marqués de Comillas, Chiapas. Informe para La Comisión Nacional Forestal, México. 33 p.

Reyes-Hernández H., S. Cortina-Villar, H. perales-Rivera, E. Kauffer-Michel, J,M. Pat Fernandez. (2003). Efecto de los subsidios agropecuarios y apoyos gubernamentales sobre la deforestación durante el período 1990-2000 en la región de Calakmul, Campeche, México. Investigaciones Geográficas, Boletín del Instituto de Geografia, UNAM 51: 88-106.

Rice R., R. Greenberg. (2004). Silvopastoral systems and socioeconomic benefits and migratory bird conservation. In: Schroth G., G.A.B. da Fonseca, C. Harvey, C. Gascon, H.L. Vasconcelos, A.N. Izac (Eds). Agroforestry and biodiversity. Conservation in tropical landscapes pp. 453-472. Island Press, Washington D.C.

Romero-Alvarado, Y., L. Soto-Pinto, L.E. García-Barrios y J. F. Barrera Gaytán. (2002). Coffee yields and soil nutrients under the shades of Inga sp. Vs. multiple species in Chiapas, Mexico. Agroforestry Systems, 54:215-224.

Roncal G. S. (2007). Almacenamiento de carbono en sistemas agroforestales en Chiapas, México. Tesis de MC. El Colegio de la Frontera Sur (Mex), 75 p.

Ruiz De Oña P.C., L. Soto-Pinto, S. Paladino, F. Morales, E. Esquivel. (2011). Constructing public policy in a participatory manner: from local carbon sequestration projects to network governance in Chiapas, Mexico. In: B. M. Kumar and P. K. R. Nair (Eds). Pp. 247-262. Carbon Sequestration in Agroforestry: Processes, Policy, and Prospects. Springer. Dordrecht.

Schejtman, A. and J. A. Berdegué. (2004). Desarrollo territorial rural. Serie Debates y Temas rurales 1. Rimisp-Centro Latinoamericano para el Desarrollo Rural. Santiago, Chile.

Soto-Pinto L., Perfecto I., Castillo-Santiago H.J. and Caballero N.J. (2000). Shade effect on coffee production at the northern Tzeltal zone of state of Chiapas, Mexico. Agricult. Ecosyst. Environ. 80: 61–69.

Soto-Pinto L., Anzueto-Martinez M., Mendoza V. J., Jimenez-Ferrer G., B. de Jong B. 2010. Carbon sequestration through agroforestry in indigenous communities of Chiapas, Mexico. Agroforestry Systems 78 (1):39-51.

Soto Pinto M.L., G. Montoya Gómez, J. F. Hernádez, T. Morales C, A. Flores, G. Jiménez Ferrer, E. Pineda D.B. (2011). Elaboración de la primera fase del sistema de evaluación de prácticas agroforestales en la Selva Lacandona. Technical Report of Consultancy to Corredor Biológico Mesoamericano 116 p.

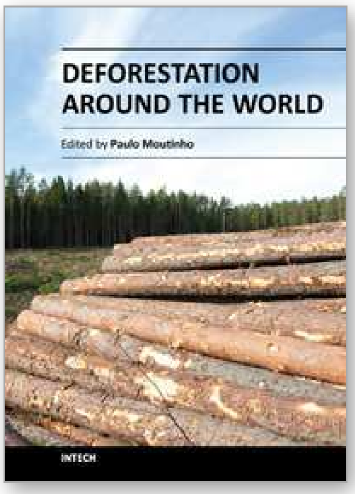
Soto-Pinto L., S. Roncal, M. Anzueto. Improved fallows as alternative to shifting cultivation in Chiapas México. Submitted.

Swiderska K., D. Row, L. Siegele, M. Grieg-Gran. (2008). The governance of nature and the nature of governance: policy that works for biodiversity and livelihoods. IIED. London, UK, 184p.

Sweeney B.W., T. Bott, J. K. Jackson, L.A. Kaplan, J. D. Newbold, L.J. Standley, W. C. Hession and R.J. Horwitz. (2004). Riparian deforestation, stream narrowing, and loss of stream ecosystem services. PNAS 101 (39) : 14132–14137.

Toledo-Aceves, T., J. A. Meave, M. González-Espinosa, N. Ramírez-Marcial. (2011). Tropical montane cloud forests: Current threats and opportunities for their conservation and sustainable management in Mexico. Journal of Environmental Management, 92 (3): 974-981.

Watson R.T, I. R. Noble, B. Bolin, N. Ravindranath H., D. J. Verardo, D.J. Dokken. (2000). Land use, lande-use change and forestry: a special report of the Intergovernmental Panel on Climate Change. World Bank, Washington D.C. 388p.



Deforestation Around the World

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Deforestation and forest degradation represent a significant fraction of the annual worldwide human-induced emission of greenhouse gases to the atmosphere, the main source of biodiversity losses and the destruction of millions of people's homes. Despite local/regional causes, its consequences are global. This book provides a general view about deforestation dynamics around the world, incorporating analyses of its causes, impacts and actions to prevent it. Its 17 Chapters, organized in three sections, refer to deforestation impacts on climate, soil, biodiversity and human population, but also describe several initiatives to prevent it. A special emphasis is given to different remote-sensing and mapping techniques that could be used as a source for decision-makers and society to promote forest conservation and control deforestation.